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ABSTRACT

This Issue Paper includes two papers: (1) "What Can Research on Teacher Thinking Contribute to Teacher Preparation? A Second Opinion," by Robert E. Floden and Hans Gerhard Klinzing, and (2) "Taking Account of the Distinction between Knowing and Thinking in Teaching," by Magdalene Lampert and Christopher Clark. Both sets of authors are working to discern the ways in which research can contribute to practice and improvements in practice. The Floden/Klinzing paper reviews literature on this topic, taking issue in particular with earlier work by Lampert and Clark. The Lampert/Clark paper is less a rebuttal to Floden and Klinzing than an effort to clarify and further develop their own ideas. The content of these papers should help readers in a variety of contexts better understand the relationship between research and teaching. (Author/JD)

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Issue Paper 90-4

Two Views of the Role of Research on Teacher Thinking

Robert E. Floden and Hans Gerhard Klinzing;
Magdalene Lampert and Christopher Clark

NCRTE

National
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Issue Paper 90-4

TWO VIEWS OF THE ROLE OF RESEARCH ON TEACHER THINKING

Robert E. Floden and Hans Gerhard Klinzing;
Magdalene Lampert and Christopher Clark

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Abstract

This Issue Paper includes two papers, one by Robert E. Floden and Hans Gerhard Klinzing, the other by Magdalene Lampert and Christopher Clark. Both sets of authors are working to discern the way(s) in which research can contribute to practice and to improvements in practice. The Floden/Klinzing paper reviews literature on this topic, taking issue in particular with earlier work by Lampert and Clark. The Lampert/Clark paper is less a rebuttal to Floden and Klinzing than an effort to clarify and further develop their own ideas. The conversation among these authors should help readers in a variety of contexts better understand this important issue.

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WHAT CAN RESEARCH ON TEACHER THINKING CONTRIBUTE TO TEACHER PREPARATION? A SECOND OPINION

Robert E. Floden and Hans Gerhard Klinzing[1]

A decade or so ago, researchers on teaching began to extend their attention to encompass teachers' thoughts, as well as their behavior. Their intention was presumably to improve educational scholarship and practice by providing a more complete account of teachers' actions, their sources, and their effects. Some progress has been made toward those goals, though methodological difficulties and the decrease in financial support for educational research limited the volume of research during the 1980s.

An unanticipated consequence of this shift in research concentration has been a reduction in the expectations some researchers hold for the contributions of research to the practice of teacher education. A decade ago, researchers (e.g., Gage, 1978; Medley, 1977) were optimistic about the contributions they could make to the improvement of teacher education; practitioners seemed hopeful, even if skeptical, about the prospect for practical applications. Now the tables seem to have turned. Although "research-based" descriptions of effective teaching actions are used in teacher education (e.g., Smith, 1984) and form the basis of state-prescribed teacher competencies, some prominent researchers (e.g., Clark, 1988; Clark and Lampert, 1986; Shulman, 1986, 1987) are skeptical. Similarly, although some reviewers (e.g., Bromme and Brophy, 1986; Corno and Edelstein, 1987; Shavelson, 1983) are optimistic about the significance of research on teacher *thinking* for teacher education, others question the practical value of what has been learned, at least from studies completed so far. Clark and Peterson (1986) stressed the limited amount of research done to date, a condition which leads to vague, nonsurprising conclusions--for example, the conclusion that "thinking plays an important part in teaching" (p. 292). Shulman (1986) concludes that the research on teacher thinking has so far brought little of value to teaching or teacher education, because it has focused on areas of thought that have little practical or scientific importance.

With the experts disagreeing, the arguments behind optimistic and pessimistic conclusions must be examined to make a reasoned assessment of the contributions research on teacher thinking has and could make to teacher education. After considering the major reasons given for claiming that contributions must be severely limited, we discuss the potential that this research has for improving several aspects of teacher education. Our analysis will draw examples primarily from the research on teacher thinking that Shulman (1986) describes as the research program of "teacher cognition and decision making." These

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research studies use methods such as process tracing, thinking aloud, policy capturing, and stimulated recall to understand teachers' thought processes. Extensive reviews of this literature have been provided by Clark and Peterson (1986) and by Shavelson and Stern (1981).

Two recent reviews (Clark, 1988; Clark and Lampert, 1986) deserve special consideration, because they suggest that the lack of new knowledge about teacher thinking for use in teacher education is an endemic problem not likely to be solved by further research. If these reviews are right, they suggest that resources now devoted to research on teacher thinking be moved elsewhere, at least as far as the improvement of teacher education is concerned. These reviews are not the product of individuals marginal to the field, taking potshots at a research domain they fail to understand. The review by Clark and Lampert won the American Educational Research Association award for research-into-practice, and the more recent paper by Clark was first presented as an invited address to the international organization devoted to research on teacher thinking (the International Study Association on Teacher Thinking, which Clark helped found) and was later published as an *Education Researcher* lead article.

These two papers seem to imply a dramatic shift in the earlier conception of the relationship between research on teacher thinking and teacher education. They advocate abandoning teacher education based on behavioral research, on the grounds that it leads to overly simple prescriptions for teacher performance. Such research, they claim, shows that teaching is too complex for any research-based prescriptions. At best, such research can be "a stimulus for thought in support of self-directed development" (Clark and Lampert, 1986, p. 30), can contribute observational methods that teachers can use, and can provide descriptions that can help teachers better understand their own patterns of thinking and acting. In an apparent embrace of relativism, they advocate letting teachers be the only judge of their own teaching and only providing teachers with conceptual tools for understanding each particular teaching situation. Research can pose questions, but teachers and teacher educators themselves must provide the answers.

This conclusion about the value of past teacher education, of process-product research, and even of research on teacher thinking is too pessimistic. It is inappropriate to turn research results into teaching prescriptions and teacher testing systems; but research knowledge still can and should play a substantive, constructive role in teacher education. Moreover, the pessimistic conclusion does not recognize the danger of encouraging complete reliance on personal (often idiosyncratic) experience as a basis for teaching (see Buchmann, 1986).

While we agree that results from *any* research tradition can be inappropriately converted into simplistic prescriptions (Fenstermacher, 1978; Floden and Feiman, 1981; Zumwalt, 1982), we think that casting research as no more than "food for thought" is

dangerously overcautious. A more appropriate view of the possible contributions of research will help teacher educators and teachers benefit from research and in turn provide guidance for researchers who hope to conduct research with value for teacher education. In arguing that research can make contributions to teacher education, we will examine arguments made against such present or potential contributions of research, showing how the dangers that give rise to these fears can be avoided without simultaneously eschewing the positive contributions of research.

Finding the Middle Ground Between Prescription and Rationalization

The reviews of Clark (1988) and Clark and Lampert (1986) have argued that research on teacher thinking can provide no guidance for the content of teacher education. Rather than providing teacher educators with information about the relative merits of different patterns of teacher thought or action, they say, researchers merely "provide food for thought responsive to the perceived needs of teacher educators" (Clark, 1988, p. 6). Research can remind teachers and teacher educators that teaching is complex, demanding, and uncertain, they say; but "research cannot describe the sorts of decisions teachers should be taught to make in any particular setting" (Clark and Lampert, 1986, p. 29). They say that empirical investigations that will provide guidance must be done by the teacher educators or teachers themselves, perhaps with *methodological* advice from the research community. The reviews also suggest that research will provide a rationale for existing practice, not directions for change:

> Research on teacher thinking does not constitute the ground for *radical* revision of the form and content of teacher preparation. Some of the most important contributions to teacher education may take the form of rationalizing, justifying, and understanding practices that have long been in place in teacher education. (Clark, 1988, p. 6)

Three interrelated lines of thought led the reviewers to these conclusions. Careful examination of each will show that research can contribute more than merely food for thought and good questions (though both are important) without being used inappropriately. We hope to show that the proper role for research lies in a middle ground between "radical" prescription and rationalization of the status quo. One argument against the value of research is that teaching is so complex and variable that no generalizations from research are helpful in the particular contexts and situations teachers experience:

> Teachers work in situations where they are expected to accomplish complex and even conflicting goals. Under these circumstances, a priori knowledge identified by researchers about the relationship among particular decisions or

actions and their outcomes is of limited worth. (Clark and Lampert, 1986, p. 28)

Teaching is complex, and the variation among teaching situations does preclude (perhaps in principle) knowledge about relationships between goals, decisions, actions, and outcomes. Imperfect relationships, or variability and uncertainty, do not, however, mean that knowledge about general tendencies and associations is useless. It is better to have *some* information about what is more likely to happen than to have no information at all. Discussing the value of process-product research on teaching, Gage (1985) argues forcefully that knowledge of general tendencies provides an important addition to teachers' knowledge. The value of such information is determined by how much it reduces teachers' uncertainty. It will never eliminate the uncertainty (Floden and Clark, 1988) but may often provide valuable, important information.

A second argument against the value of research is that, if research results are used to do more than suggest concepts and questions, they will be converted into technical prescriptions that impede the flexibility teaching requires and degrade teachers' professionalism. This (false) dichotomy is illustrated in Clark's (1988) description of the "three ways to characterize the relationship between research on teaching, on the one hand, and teacher education, on the other hand" (p. 5). First, research and teacher education may be entirely separate. Second, research results may be used to "train prospective teachers to behave in the ways that research has shown to be most effective in producing achievement gains in students" (p. 5). Third, researchers may provide food for thought and pose questions.

We agree with Clark in rejecting the first option, though at least one prominent researcher has argued in its favor (Kerlinger, 1977). The dangers of the second sort of relationship have been discussed by many authors (e.g., Fenstermacher, 1978; Floden, 1985; Zumwalt, 1982). Training teachers to follow a fixed set of prescriptions discourages teachers from adapting their instruction to the particular subjects and students they are teaching. Hence the instructional effectiveness of teachers given such training is unlikely to be high. In addition, this mechanical approach to teaching degrades the self-concepts and professional standing of teachers. Moreover, the uses of research results by state certification boards have led to the "currently incomplete and trivial definitions of good education held by the policy community" (Shulman, 1987, p. 20). These misuses of research results provide good grounds for the fear that reliance on research can lead to a simplistic model of the relationship between research on teaching and teacher education.

But rejecting the first two possibilities does not require abandoning hope of telling teacher educators anything useful. Knowledge about general tendencies is better than no knowledge. It is even more valuable if teachers have opportunities to discuss how those

general tendencies were determined--what methods, assumptions, and goals were used or assumed by those carrying out the research. Understanding and discussing research results (as advocated by, e.g., Zumwalt, 1982) provides teachers with knowledge, without reducing them to puppets manipulated by policymakers or researchers. In the middle ground between Clark's second and third options, research can be seen as a source of general--but not binding--recommendations for action. These recommendations are answers, not merely questions; they provide a general direction to be thoughtfully followed, not mere food for thought. They may suggest substantial changes in teacher education practice, rather than providing reasons for maintaining the status quo.

A third argument, implicit in some of these skeptical articles, is that teachers act reasonably within the situations they construct. Thus, research on teacher thinking has made that reasonableness explicit, showing that teachers often act on the basis of reasons and reasoning. But that conclusion does not imply that the reasons or reasoning are necessarily appropriate, valid, or logical, or that they will lead to effective action. Indeed, the research often reveals that teachers do not act in the best manner to achieve their own goals or that teachers do not have accurate information or "theories" about their students or about their own actions. Research can serve to supply more valid concepts or principles, which may not perfectly fit a particular teaching situation, but can serve as well-founded hypotheses for use in the teachers' experimentation.

A fourth argument against the value of research on teacher thinking is that it has been restricted to small-sample descriptive studies on topics of little importance. In their recent comprehensive review, Clark and Peterson (1986) point out that too few studies have been done and that only a handful have attempted to examine the relationships between teacher thoughts and student learning. Clark and Lampert (1986) see the small number of studies as a disadvantage but offer little hope that a greater number of studies would remove fundamental barriers to the value of research for teacher education.

Descriptive, static studies of teachers provide little basis for advising teachers about how to improve their practice, even when the studies describe differences between novice and experienced teachers (Floden and Feiman, 1981). But this difficulty is due to the current state of progress in the research on teacher thinking, not to some inherent gulf between such research and the practice of teacher education. Research on the planning, judgment, and decision-making strategies of large samples of expert (rather than merely experienced) teachers could provide information about which ways of thinking tended to be associated with teaching that led to improvements in pupil learning.

Information linking teachers' thinking with student learning could provide teacher educators with empirically based suggestions about what habits of mind they would like to encourage in their teachers. That knowledge alone would not indicate what possibilities for developing those habits of mind should be used but would provide criteria against which to

judge the success of alternative approaches. Descriptive studies of how teachers acquired their expertise would also be helpful to teacher educators trying to promote such development. Even more helpful would be studies that compared alternative strategies for promoting desirable changes in teachers' thinking. The contributions of these various sorts of research may be clarified by considering how research might contribute to the content, methods, and policies of teacher education.

Possible Contributions of Research on Teacher Thinking

Research on teacher thinking might affect teacher education in at least three ways. First, it might be a valuable source of teacher education *content*. Second, it might give teacher educators insight into the processes of teacher learning and functioning, insight that could help them plan *methods* of teacher education instruction. Finally, the research might influence educational *policies* that are important to teacher educators (e.g., policies for teacher testing).

In all three cases, the research conducted to date does not always supply the needed information about teachers' mental processes. But a consideration of how research *could* provide information for teacher educators shows that such help is not precluded in principle. It also shows the directions in which research would have to move in order to have immediate value for teacher education. As is shown below, some researchers are already taking steps in these directions.

The Content of Teacher Education

How might research on teacher thinking suggest modifications in the content of teacher education? Consideration of more general cognitive views of teaching and learning suggests that more attention be given to the schemata (see, e.g., Anderson, 1984; Floden, 1989) that teachers use to impose meaning on teaching situations. Teaching skills still need to be mastered, but goals and schemata must be used to select, adapt, and integrate these skills to meet the demands of specific situations.

Attention to schemata will involve additions to the content to be learned. In other cases, schemata will already be a part of the curriculum content (e.g., the schemata of "responding to partially correct pupil answers" or "dealing with an aggressive child"). Research supports the idea that such schemata function as an important part of teachers' mental processes; the task for teacher education is to help teachers learn the schemata best suited to achieving their instructional aims. To date, research on teacher thinking has seldom attempted to identify those desired schemata. Research in this direction could provide specific content for teacher education.

In particular, researchers have begun to document the particular routines and schemata used by effective teachers in their instruction (e.g., Berliner and Carter, 1986). If

research linking schemata and routines to student progress were to match the accomplishments of process-product research, these new studies could suggest empirically supported teacher education content with value similar to that of the results of process-product research. The schemata may guide teachers' hypotheses about which routines can be best adapted for specific teaching situations and goals. A broad repertoire of routines not only gives teachers a basis for responding to expected and unexpected classroom events, but it also gives them a good starting point for acting creatively. "The performance of experts, though not necessarily perfect, provides a place to start from when we instruct novices" (Berliner, 1986, p. 6).

As mentioned earlier, this specific content should not be treated as prescriptions for the particular thought patterns teachers ought always to use (Floden and Feiman, 1981). Teachers should certainly take account, as well as they can, of how their specific goals and circumstances differ from those under which the research was conducted. But patterns of thought or action that have proven effective in a large number of similar situations provide a sounder starting point than decisions or actions based only on individual experience, chance, misconception, or prejudice. Providing these results as research-based hypotheses for action is a more substantial contribution to teacher education practice than simply posing questions or providing "food for thought." Unless questions are posed rhetorically, asking questions provides no information about what researchers have found out.

Research methods themselves may also be an important addition to the content of teacher education. Clark and Lampert (1986) are right to assert that research methods are valuable for teachers. Their conception of how research methods should be used can, however, be extended. Such methods cannot only help teachers understand their practice; but an ability to conduct systematic inquiry can also help them judge how they should appropriately adapt general teaching principles to a specific teaching context. Research on teacher thinking also suggests that teachers use routines to carry out (with situational adaptations) tasks they frequently confront. As with schemata, recognizing the importance of routines may suggest the need for new content or additional emphasis on, or modification of, existing content. These changes should attend to the demands of actual classroom instruction and distinguish desirable routines from merely functional ones.

The case of teacher planning provides a concrete example in which current research has studied a particular set of routines in detail. The results are instructive. The most widely cited results of research on planning are that planning does affect instruction and that teachers do not follow the "rational" planning model. What should teacher educators make of these results? The first result (together with the finding that teachers *do* have routine patterns of planning) suggests that teacher educators have been right in thinking that planning should occupy an important place in teacher preparation.

The second result suggests that past efforts to teach planning routines have been in some way unrealistic. Researchers have often concluded that teachers' failure to follow the planning model they were taught stems from a mismatch between that model and the combination of the demands of classroom instruction and the working conditions of teachers. Given the importance of planning, it seems important to work on developing new ways of teaching planning routines, ways that will be better suited to practice and to teachers' working conditions. Again, current research has not yet provided concrete suggestions for these routines. Perhaps the best teacher educators can do now is to help teachers revise the rational planning model so that it can be suited to practice without completely losing its desirable emphasis on the relationship between teaching aims and instructional choices.

Research highlights the importance of subject-matter understanding for teaching. Leinhardt and Smith (1985) and Shulman (1987) emphasized the significance of teachers' ability to represent subject matter in ways that address pupils' particular difficulties with learning. This work suggests the need for more emphasis on some aspects of subject-matter knowledge in teacher education (see also Buchmann, 1984). In the United States, more emphasis on all aspects of subject-matter knowledge may be indicated, particularly for elementary school teachers; for European countries, where more extensive study of subject matter is already the rule, what may be needed is more emphasis on those aspects of subject matter that are specific to the curriculum in schools.

Methods of Teacher Education

As many researchers have suggested, one important way for teachers and teacher educators to improve practice is for them to try out systematically various approaches in their own practice. Requiring that every teacher educator ignore previous research and "rediscover the wheel," however, is wasteful and unworkable. Even though teacher education is as complicated as teaching (if not more so), some general tendencies exist; and it would be a waste of teacher educators' time to establish each of these tendencies independently (though establishing a few for themselves may yield the benefits that come from discovery).

Instead of researchers' asking teacher educators to discover the implicit theories of their own students, for example, researchers might conduct studies (e.g., Ball, 1988) that describe in some detail the implicit theories of many students. Teacher educators could then decide whether to spend their available time for research to see how far their own students differ from the norm or to do something related to ways in which their curriculum is unique.

Some already available research may provide more than food for thought to teacher educators. More may be known about how to help teachers acquire routines and schemata than about which content would be most worth acquiring. Research on how teachers learn to teach and on teachers' actions and thoughts has recently increased. It has, for example, described the thinking of experienced teachers, compared that thinking with that of novices

(Berliner, 1986; Berliner and Carter, 1986), and described how novices get to be experts--if they ever do--(e.g., National Center for Research on Teacher Education, 1988; Shulman, 1987; Zeichner and Tabachnick, 1984).

As such studies of teacher learning progress, teacher educators may be especially interested in studies that describe how teachers learn routines and schemata. An understanding of these learning processes would give teacher educators positive guidance in selecting or designing methods for working with teachers. They could avoid teacher education methods that seem unlikely to help with most teachers and devote their energies to adapting techniques that seem more likely to work, at least much of the time.

Although research on teacher thinking per se still contains few studies of teachers' learning of routines and schemata, some help comes from studies of ways of teaching skills and concepts to teachers. These studies were often done within the context of behavioral conceptions of learning and have been appropriately criticized for not taking teachers' mental processes into account. Methods shown to be successful in teaching skills and concepts should not, however, be discarded because they were narrowly conceived. Instead, teacher educators should consider how the success of these methods can be understood (the teachers must have been thinking and must have changed how they thought) in cognitive terms and should think about whether the methods could be used in helping teachers acquire potentially helpful routines and schemata.

Although some process-product research and microteaching may have disregarded thought processes (some early literature encourages such an interpretation), a cognitive reinterpretation permits a better understanding of some apparent inconsistencies in past research (Clark and Peterson, 1986) and explains the significance of the conceptual development phase now incorporated into laboratory methods of teacher education (Joyce and Showers, 1980; Klinzing, 1982). The processes of learning specific routines and schemata may well be improved through training approaches such as microteaching, cognitively redeveloped and reinterpreted. Some researchers have already pointed out the potential of such methods (e.g., discrimination training, teaching laboratories; see Bromme and Brophy, 1986).

Methods for training discrimination and perception seem likely to be useful in helping teachers to learn schemata for imposing goal-related structures on the instructional context. Cognitive research on teaching has provided an additional perspective on the value of concepts, but the general formulation of the concepts is sufficiently similar to previous formulations to encourage exploration of previously validated training methods. Thus some research is already available to suggest promising starting points for developing teacher education methods to help teachers acquire routines and schemata. Teacher educators can learn from this research, which provides suggestions for practice, rather than merely food for thought.

Policies in Teacher Education

Research on teacher thinking may also inform policies in teacher education. The general argument here is much the same as in the cases of content and methods of teacher education. Research cannot provide simple prescriptions valid for all specific cases; it can, however, provide more than questions and food for thought. Most descriptive studies conducted to date may, indeed, provide only food for thought. But this problem may yield to research on changes in teacher knowledge, the sources of such changes, and the relationships between teacher cognitions and the attainment of goals of schooling (e.g., pupil achievement).

This general argument may be illustrated with policies in teacher testing. For good or for ill, it seems likely that many U.S. teachers--beginners and veterans--will be subject to mandated examinations or will have career progress linked to their test performance. As Shulman (1987) points out, those writing the exams may exaggerate the certainty and generality of research results, thus inappropriately constricting the range of appropriate teacher responses. This seems a clear example of the problems that lead some researchers to avoid claiming any substantive role for research results.

Deciding how narrowly the "right" answer should be cast is, however, a general dilemma in test construction, rather than a danger specific to knowledge based on research. Test designers must always manage the tension between giving credit for creative, divergent answers and denying credit for answers that seem to indicate misunderstandings of central concepts. This tension is greater (or at least more evident) when the number of students to be graded requires explicit written or oral discussions about what will or will not be acceptable. The dilemma must be resolved, however, even for a single instructor grading essay exams of a dozen students.

If decisions about teachers are to be based--at least in part--on examinations, then someone must decide what knowledge and skills are to be assessed. Denying that research on teacher thinking can provide any guidance about what teachers should know or be able to do will avoid oversimplification and overgeneralization of *research* results but will still permit oversimplification and overgeneralization of whatever base is used to select test content. A variety of sources will probably be used--tradition, common sense, judgments of people of standing in the field, personal experience, logical analysis. Research has advantages over many other sources, because procedures for guarding against error are embodied in the canons of research. More important, each of these other sources is also susceptible to the same dangers of oversimplification and overgeneralization. If a test is to be constructed, in other words, denying that research results should be used in test construction does not avoid overly narrow, prescriptive tests; it merely bases those prescriptions on beliefs that lack a grounding in systematic inquiry.

Critics might object that research results are particularly problematic because their connection with research makes them less open to challenge; that is, the claim that a test is "based on research results" limits debate to people with advanced training in research. An exam with content based on personal experience or common sense, however, is open to discussion by a much wider field. Hence the process of test development is more democratic.

This argument has a kernel of truth. If the validity of research results is supported only by the general authority of research, discussion is closed off. The apparently preferable character of discussions based on personal experience, for example, is undercut, however, by the undesirable criteria likely to be used for resolving such discussions. In an exchange of personal experiences, the one that carries the day will be determined by some combination of persuasive rhetoric and authority. The decision is no more likely to be based on sound reasoning than that based on an invocation of the mystique of research. Research results at least have the potential for providing a tentative basis for decisions that can be challenged on the basis of conflicting evidence or considerations of the validity of arguments.

Giving Teacher Educators Due Credit and a Proper Role

Reluctance to think that research can provide informative suggestions for the content or process of teacher education may represent a reaction against perceptions that researchers have been talking down to teacher educators, presuming to dictate their practice. (For an example of such presumption, see Joyce and Clift, 1984.) Thoughtful teacher educators probably know some important things that researchers do not about teacher education. Indeed, more studies are needed to tap the wisdom of practice possessed by teacher educators. The intention to give teacher educators due (and probably long overdue) credit for what they know is admirable. Teacher educators have too often borne the brunt of sharp criticism of the education community (e.g., Bestor, 1955; Koerner, 1963). But teacher educators can be given credit for their wisdom without denying that systematic research can provide information that individual teacher educators are unlikely, or unable, to acquire through individual experience or sharing ideas with colleagues. The central results of research on teacher planning, for example, may have been news to many teacher educators who had been teaching a linear planning model to their students.

It is probably unlikely that research on teacher thinking will bring about radical revisions in the general practice of teacher education, though that possibility should not be ruled out a priori. Given the wide variation in teacher education practice, however, it is quite possible that research could strongly suggest radical revision in the practice of some teacher educators. The fact that most teacher educators have developed approaches that they find comfortably "functional," should not be confused with the assertion that all "functional" practices are appropriate. Researchers would be overly modest to claim that

they have learned nothing but how to ask questions (cf. Floden, 1985). If all that research on teacher thinking can contribute is the ability to pose questions such as, "What are the preconceptions about teaching and learning held by our students?" (Clark, 1988, p. 7), then the research is probably not worth doing. Such questions could be posed with no knowledge of research on teacher thinking. Research on teacher thinking that is worth the effort should be able to provide at least general, even if imprecise, answers to such questions.

References

Anderson, R. C. (1984). Some reflections on the acquisition of knowledge. *Educational Researcher, 13*(9), 5-10.

Ball, D. L. (1988). *Knowledge and reasoning in mathematical pedagogy: Examining what prospective teachers bring to teacher education*. Unpublished doctoral dissertation, Michigan State University.

Berliner, D. C. (1986). In pursuit of the expert pedagogue. *Educational Researcher, 15*(7), 5-13.

Berliner, D. C., and Carter, K. J. (1986, October). *Differences in processing classroom information by expert and novice teachers*. Paper presented at the meeting of the International Study Association on Teacher Thinking, Leuven, Belgium.

Bestor, A. (1955). *The restoration of learning*. New York: Knopf.

Bromme, R., and Brophy, J. (1986). Teachers' cognitive activities. In B. Christiansen, G. Howson, and M. Otte (Eds.), *Perspectives on mathematics education* (pp. 99-140). Dordrecht, The Netherlands: Reidel.

Buchmann, M. (1984). The priority of knowledge and understanding in teaching. In L. G. Katz and J. D. Raths (Eds.), *Advances in teacher education* (Vol. 1, pp. 29-50). Norwood, NJ: Ablex.

Buchmann, M. (1986). Role over person. *Teachers College Record, 87*, 529-543.

Clark, C. M. (1988). Asking the right questions about teacher preparation: Contributions of research on teacher thinking. *Educational Researcher, 17*(2), 5-12.

Clark, C., and Lampert, M. (1986). The study of teacher thinking: Implications for teacher education. *Journal of Teacher Education, 37*(5), 27-31.

Clark, C. M., and Peterson, P. L. (1986). Teachers' thought processes. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 255-296). New York: Macmillan.

Corno, L., and Edelstein, M. (1987). Information processing models. In M. Dunkin (Ed.), *The international encyclopedia of teaching and teacher education*. New York: Pergamon.

Fenstermacher, G. D. (1978). In L. S. Shulman (Ed.), *Review of research in education* (Vol. 6, pp. 157-185). Itasca, IL: Peacock.

Floden, R. E. (1985). The role of rhetoric in changing teachers' beliefs. *Teaching and Teacher Education, 1*, 19-32.

Floden, R. E. (1989). What teachers need to know about learning. In *Competing visions of teacher knowledge: Proceedings from an NCRTE seminar for education policymakers. Volume 2: Student diversity* (Conference Series 89-1, pp. 1-22). East Lansing: Michigan State University, National Center for Research on Teacher Education.

Floden, R. E., and Clark, C. M. (1988). Preparing teachers for uncertainty. *Teachers College Record, 89*, 505-524.

Floden, R. E., and Feiman, S. (1981). Should teachers be taught to be rational? *Journal of Education for Teaching, 7*, 274-283.

Gage, N. L. (1978). *The scientific basis of the art of teaching*. New York: Teachers College Press.

Gage, N. L. (1985). *Hard gains in the soft sciences: The case of pedagogy*. Bloomington, IN: Phi Delta Kappa.

Joyce, B., and Clift, R. (1984). The Phoenix agenda: Essential reform in teacher education. *Educational Researcher, 13*(4), 5-18.

Joyce, B., and Showers, B. (1980). Improving inservice training: The message of research. *Educational Leadership, 37*, 379-85.

Kerlinger, F. N. (1977). The influence of research on education practice. *Educational Researcher, 6*(6), 5-12.

Klinzing, H. G. (1982). *Training kommünikativ Fertigkeiten zur Gesprächsführung und für Unterricht [Training of communication skills for discussion and instruction]*. Weil der Stadt, Federal Republic of Germany: Lexika.

Koerner, J. D. (1963). *The miseducation of American teachers*. Boston: Houghton Mifflin.

Leinhardt, G., and Smith, D. A. (1985). Expertise in mathematics instruction: Subject matter knowledge. *Journal of Educational Psychology, 77*, 247-271.

Medley, D. M. (1977). *Teacher competence and teacher effectiveness: A review of process-product research*. Washington, DC: American Association of Colleges for Teacher Education.

National Center for Research on Teacher Education (1988). Teacher education and learning to teach: A research agenda. *Journal of Teacher Education, 39*(6), 27-32.

Shavelson, R. J. (1983). Review of research on teachers' pedagogical judgments, plans, and decisions. *Elementary School Journal, 83*, 392-413.

Shavelson, R. J., and Stern, P. (1981). Research on teachers' pedagogical thoughts, judgments, decisions, and behavior. *Review of Educational Research, 51*, 455-498.

Shulman, L. S. (1986). In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 3-36). New York: Macmillan.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*, 1-22.

Smith, D. C. (1984). PROTEACH: Teacher preparation at the University of Florida. *Teacher Education and Practice, 1*(2), 5-12.

Zeichner, K. M., and Tabachnick, B. R. (1984). *The development of teacher perspectives: Social strategies and institutional control in the socialization of beginning teachers.* Madison: University of Wisconsin.

Zumwalt, K. K. (1982). Research on teaching: Policy implications for teacher education. In A. Lieberman and M. McLaughlin (Eds.), *Policy making in education* (The 81st yearbook of the National Society for the Study of Education, pp. 215-248). Chicago: University of Chicago Press.

TAKING ACCOUNT OF THE DISTINCTION BETWEEN KNOWING AND THINKING IN TEACHING

Magdalene Lampert and Christopher Clark[2]

Floden and Klinzing argue that we ought to be more optimistic about what research on teacher thinking can contribute to teacher education. They accuse us of "unnecessary pessimism" when we assert that the research on teacher thinking that was available in 1986 and 1987 could not tell teacher educators how to teach novices in the profession the kind of thinking that could predictably produce student learning. In fact, we were quite optimistic about teachers and teacher educators learning from research on teacher thinking--but we had a different set of research in mind, and perhaps a different idea of what it is that teachers and teacher educators need to learn about thinking in teaching practice.

Floden and Klinzing also accuse us of "relativism" because we suggest that teachers need to evaluate their knowledge in terms of its usefulness for the situation in which they find themselves. At the same time, Floden and Klinzing themselves recognize the dangers in the generalization of research findings by policymakers, but they do not seem to extend their thinking in the direction of constructive alternatives that might involve teachers developing their professional knowledge in the context in which knowledge is used. Contextually grounded work by practitioners in the service of finding local solutions to local problems is not the same as rampant relativism, and indeed, policy analysts have found contextually constructed strategies to be a more effective route to teacher change (Berman and McLaughlin, 1978; Loucks-Horsley et al., 1987).

One of the grounds on which Floden and Klinzing accuse us of pessimism is our assertion that research can provide teachers and teacher educators with "food for thought," or in their terms, "*merely* food for thought." Their argument seems to suggest that teachers and teacher educators cannot or will not make use of food for thought, or that such "food" would not make much of a contribution to their practice. Recently Buchmann (1989) has argued for the positive benefits of *contemplation* in the practice of teaching, and her argument seems a similar, if more cogent, expression of what we had in mind.

As they cast about for ways in which research on teacher thinking might suggest modifications in teacher education, Floden and Klinzing speculate that "research on the planning, judgment, and decision-making strategies of large samples of expert (rather than merely experienced) teachers could provide information about which ways of thinking tended to be associated with teaching that led to improvements in pupil learning" (p. 5). They go

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on to recommend that future research ought to determine the "schemata" that underlie "expert" teachers' actions, and they conclude that even if extant research on teacher thinking cannot suggest the content of teacher education, such future studies will be able to do so. We have two problems with this speculation. One problem has to do with how experts *learn to use* schemata of the sort that Floden and Klinzing describe to guide their actions. The other has to do with deciding *who is an expert* at teaching.

Teacher Knowledge and Teacher Thinking

Floden and Klinzing's argument glosses over the distinction between *teacher knowledge* and *teacher thinking*. Indeed, this distinction was not entirely clear in our original essays. In rethinking the arguments we made on the uses of research on teacher thinking in teacher education, however, we have come to recognize some important differences between knowledge and thinking. In the work that Floden and Klinzing consider, we asserted that one thing we have learned from research on teacher thinking is that teaching is a complex act requiring the moment-by-moment adjustment of plans to fit continually changing and uncertain conditions--these adjustments are acts of teacher thinking. We characterized the knowledge teachers use in making those adjustments as *contextual, interactive, and speculative*. What we were trying to say might have been clearer if we had said instead that *the way in which teachers use knowledge* is contextual, interactive, and speculative. We did not, and would not now, argue that teachers do not need or have or use schemata (i.e., knowledge of general tendencies and associations); rather we would argue that if novices are going to learn to use such knowledge in practice (i.e., *to think* like teachers at work), we might want to consider designing teacher education with that aim in mind, and this means raising questions about whether knowing what an expert knows is the same as knowing how an expert thinks.

The research on teacher thinking we reviewed is research about what it means to think like a teacher at work. In order to be an effective preparation for practice, teacher education needs to be designed with the practical goal of educating novices to think like teachers. Here we would like to consider what has been learned about the general question of how experts use their knowledge in practice--i.e., *how they think*--and briefly consider what this might imply for teacher education. And then we would like to raise another thorny question suggested by Floden and Klinzing's argument: *Who* is to be considered an expert (as opposed to a merely experienced) teacher?

Studies of Managerial and Academic Problem Solving

In her recent study of work in a variety of large corporate settings, Zuboff (1988) compared practices which were relatively easy to schematize and those that were not with an eye toward figuring out where technology might be used effectively in the workplace. She

found important differences between the way knowledge was used in jobs that involved "acting on" materials, numbers, and machinery and the way knowledge was used in jobs that entailed "acting with" other people to get the work done. Teaching has been recognized as the latter kind of activity for several decades (Bidwell, 1965; Parsons, 1959) although its status as a "people-changing profession" is receiving renewed attention (Bereiter and Scardamalia, 1989; Brown, 1989; Cohen, 1988; Jackson, 1988).

Zuboff (1988) and others (e.g., Isenberg, 1984; Kotter, 1982), who have studied the thinking of professionals whose job it is to get other people to change, have found that this sort of work involves thinking that is highly responsive to others and integrated with action rather than preparatory and schematic. Managerial thinking often occurs in the context of ad hoc oral exchanges, discussion, persuasion, and negotiation. An important component of expertise in these contexts is thinking in a way that reflects shared experience with the people one is managing and negotiating shared meanings in the context of that experience. Building trust and communication depend on a high degree of sensitivity and responsiveness to the context in which tasks are to be performed, building a feel for situations and actors.

In quite a different kind of practice, mathematics, epistemologists have recently taken up the question of what expert thinking looks like if one looks directly at *practice* as opposed to the *outcomes of practice*. They conclude that rule-based problem solving is not what leads to the best work. Intuition, the importance of context, and the tentativeness of conclusions are beginning to be recognized as at least as important to expertise as knowing the rules that lead to predictable results (Davis and Hersh, 1986; Steiner, 1988; Tymoczko, 1985). Although on the surface, the doing of mathematics may have little in common with the doing of teaching, we mention this work here because it represents a growing awareness in many fields that knowledge is interactive with the context in which it is used rather than being a fixed entity which can be acquired and applied. The development of expertise is coming to be seen by these scholars as an initiation into a community of discourse where the rules governing expert action are often unstated and interactively constructed to fit different situations. Based on both philosophical speculation and an examination of what expert practitioners are able to do in such fields as medicine, mining, and mathematics, critics of the rationalization of intelligence, such as Dreyfus and Dreyfus (1986) and Weizenbaum (1976), have asserted that the sort of reasoning on general principles, which underlies schemata theory, is not the sort of thinking that characterizes the work of experts.

As yet, the empirical and philosophical work that has led Zuboff (1988) and others to their conclusions about how experts think is rare in education. But it seems we might learn something about how to educate teachers by considering recent studies of thinking in practices with similar purposes in the corporate and academic worlds. Such studies have been occurring in cognitive psychology over the past decade, and we might also consider recent developments in this field as we contemplate the appropriateness of building a

research agenda around the hope that information about experts' "schemata" would be useful to teacher educators.

Theories of Cognition

In the phase of cognitive research referred to as the "knowledge structures" program (Greeno, 1987), psychologists assumed that what guided actions were schemata or "knowledge structures" that were in individual minds. They set themselves the task of defining these structures for various academic and practical tasks, with the idea that novices could be taught the knowledge structures that experts use, and thus become experts themselves.[3] Based on the theory of thinking as information processing, this view has the person constructing a representation of the problem to be solved and reasoning toward a solution by manipulating elements of the representation or schemata. The knowledge structures program was associated with an attempt to capture the intelligence of experts and reproduce it artificially in computer programs, so that computers could make decisions that were close to those made by human experts in various fields. This view of knowledge has been found wanting, however, and elements of an alternative theory of how people think in problem situations is beginning to develop.

The notion that expertise is *contextual* entered the theories of cognitive scientists as they tried to describe the nonformal knowledge of unschooled but highly skilled practitioners in various domains and as they examined social theories about the relationship between language and the development of thought (Brown, Collins, and Duguid, 1989; Greeno, 1989a; Stigler and Baranes, 1988).[4] Arguments about the situated nature of cognition, like arguments about the existence of schemata, are theoretical attempts to explain expertise. The theory of situated cognition suggests that all knowledge is a joint construction of mind and the situation in which the mind finds itself confronted with a problem (Clancey, in press; Greeno, 1989a, 1989b; Suchman, 1987; Winograd and Flores, 1986). Psychologists are now claiming that the theory of situated cognition goes farther toward explaining the phenomenon of expertise than the theory of knowledge structures.

Much of the attention that has been given to the contextual nature of knowledge arises from the recognition that knowledge structures gained and used successfully in one kind of context do not easily *transfer* to other contexts in which they might be relevant. The situation in which an expert thinks provides tools, and those tools shape the kind of thinking one is able to do (Cole and Griffin, 1980; Pea, 1988). Rather than imagining schemata as the driving force of action, believers in the contextual nature of knowledge talk about

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[3]For an example of attempts to do this for teaching, see Leinhardt and Greeno, 1986; Leinhardt and Smith, 1985.

[4]Some of the most influential work in this area includes Carraher, Carraher, and Schliemann, 1985; Lave, 1988; Rogoff and Lave, 1988; Scribner, 1984.

transfer in terms of the capacity to recognize what is common among situations, and they talk of intelligence as the match between what the person brings and the richness of the situations in which they find themselves.

This developing view of cognition follows many of the same thematic lines that we pursued in our examination of the research on teacher thinking available in 1986 and 1987. It underscores the argument that simply knowing how experts structure their thinking about a problem tells us little about how they *use* those knowledge structures in practice. But more importantly for teacher education, it cautions us to pay attention to how experts *acquire and learn to use* the schemata that may characterize their thinking about the problems of practice. In a recent paper, Greeno (in preparation) has constructed a metaphor for learning to become an expert that seems relevant here. He envisions the domain of knowledge that belongs to experts in a field as an environment in which there is located a collection of resources for knowing, understanding, and reasoning in the domain. Knowing, in this image, means knowing what resources are available in the environment *and being able to find them when you need them*. One needs to be able to get around in the territory, as well as having a sense of where there is to go.[5] Schemata might be thought of as one kind of resource in a domain, but there are many others, outside of the mind of the individual problem solver, to be taken advantage of.

What Might This Mean for Teacher Education?

Floden and Klinzing speculate that if research on expert teachers' schemata were available, it could provide some guidance to teacher educators about the *content* of professional preparation. Does this mean that teacher educators will design university courses to teach novices the schemata that experts use and then test their "knowledge" of those schemata on examinations? If so, we might see what they are doing (in the terms of Greeno's metaphor) as giving their students maps of the place where the students are expecting to work and then testing their ability to reproduce the maps. Teacher educators have been doing that for years, although the maps they have been handing out are perhaps not as faithful to the terrain of teaching as the ones that Floden and Klinzing expect might be produced by examining the thinking of experts. Is handing out maps really what we need to be doing in teacher education? Is that the sort of preparation that will be effective in producing teachers who can move around independently in a pedagogical environment and make independent decisions there?

We are not suggesting that having a map might not be helpful in trying to find one's way around unfamiliar territory. What we are suggesting is that we also need to think about

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[5]A similar metaphor for expert cognition has been developed by Spiro, Vispoel, Schmitz, Samarapungavan, and Boerger (1987), following the work of Wittgenstein (1953), to characterize the acquisition of knowledge in "ill-structured disciplines."

how novices might learn when and how to use maps effectively. The work we have cited above, although it does not directly address the question of acquiring expertise in teaching, raises the question of whether maps--*the content* of teacher education--can be thought about separately from the institutional arrangements in which that content is delivered. We are not questioning the assertion that research or expertise might improve the *content* of teacher education, but we would argue that it is at least as important to consider the implications of research on teacher thinking for the *form* that teacher education should take. Another way novices acquire maps of the terrain in which they will be working is in apprenticeship arrangements with experienced teachers, and it seems as if the maps they acquire in this context are the ones they use when it comes time to strike out on their own (Feiman-Nemser and Buchmann, 1985; Lortie, 1975).

Floden and Klinzing's distinction between expert and experienced teachers points to a problem with this arrangement. Novices *do learn* from experienced teachers, not because these teachers articulate their schemata, but because the novices construct their own schemata for making sense of what works in classrooms. As teacher educators with a vision of what education for children might be like, we have rejected the idea of turning students over to practicing classroom teachers for initiation to the status quo, and perhaps that is a good decision. But the research on teacher thinking in practice suggests that the alternative of teaching schemata in university courses may not hold much promise as a method of developing expertise either. Might we not try, instead, to create new forms of communication between people who know what the experts know and people who want to learn it? But that raises another difficult question.

Who is an Expert?

This question could be construed in many ways, from the abstract arguments of analytic philosophers about the elements that should determine judgments of quality in the work of teaching to the political arguments that revolve around who has the power and authority to decide what gets called "good teaching" that have burdened the project of developing a national system for recognizing professional competence. Here we will give only a small and quite localized (by subject) example of what we might be getting ourselves into as we try to cull the expert from the experienced in teaching. As a fifth-grade mathematics teacher, Lampert has been puzzling about how to interpret two disparate and seemingly contradictory views of expertise associated with different lines of research on good mathematics teaching. Both of these lines of research are more than tangential to the problem of what research on teacher thinking can contribute to teaching and teacher education. Leinhardt (1986, in press)[6] has done several studies of expert mathematics

[6]See also Leinhardt and Greeno, 1986; Leinhardt and Smith, 1985.

teaching at the elementary school level in which, among other things, she tries to get at the differences between the schemata that underlie expert action and the schemata that are used by novices. One of the much touted findings of this research is that experts are more able than novices to cover a large number of problems with their students in each class period. Leinhardt attributes this to the cohesiveness and flexibility with which experts are able to move through the agenda of a lesson in contrast to novices' more fragmented activity. Leinhardt's work in this area is congruent with the findings of Good, Grouws, and Ebmeier (1983), who studied the teaching of expert mathematics teachers with an eye toward teaching less expert teachers how to produce more successful students. The way experts think in these studies enables them to get through a great deal more of the curriculum in each class period than novices.

But contrast this with the findings of the large scale study by Stevenson, Lee, and Stigler (1986) comparing mathematics teaching and learning in Japan, China, and the United States. If one takes student achievement as the measure of teacher expertise, the Japanese teachers are clearly the "most" expert. But what do they do? One, maybe two or three problems in each class period! Given similar measures of expertise, these two lines of work produce very different pictures of expert mathematics teaching, and by extrapolation, expert mathematics teacher thinking. Work on how Japanese mathematics teachers *think* hasn't been done, although Stigler and his Japanese colleagues seem to be moving in that direction. When they finish their work, will teacher educators be handed a new curriculum?

Changing Institutional Arrangements

Our proposal that teacher education takes account of not only the content of expert teachers' thinking but also the conditions under which they think and use knowledge does not solve the problem of who gets to be called an expert and why. But changing the institutional arrangements in which novices learn from experts might contribute to our thinking about how to define expertise. It might also confuse matters even further by suggesting that one element of expertise is the capacity to guide the professional growth of novices. Nonetheless, we remain optimistic that research on teacher thought and action in the context of practice will be of value to teachers and teacher educators.

This research and the discourse that has grown up around it has prompted teachers, teacher educators, and policymakers to ask and answer new questions about their practices and to use new methods in examining and reflecting on teaching. Reforms such as the use of case methods in professional preparation, school-based teacher education, professional development schools, and mentoring programs could all be thought of as attempts to alter the arrangements whereby novices come in contact with experts' knowledge in the direction of paying more attention to how good teachers think in the context in which they do their work. These experiments suggest that research on teacher thinking promises to make

teacher education more difficult rather than easier, but recognizing the difficulties in this work should not be confused with pessimism.

References

Ball, D. (1988). Unlearning to teach mathematics. *For the Learning of Mathematics, 8*(1), 40-48.

Bereiter, C., and Scardamalia, M. (1989). Intentional learning as a goal of instruction. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 361-392). Hillsdale, NJ: Erlbaum.

Berman, P., and McLaughlin, M. W. (1978). *Federal programs supporting educational change. Vol. 8: Implementing and sustaining innovations*. Santa Monica: Rand Corporation.

Bidwell, C. E. (1965). The school as a formal organization. In J. G. March (Ed.), *Handbook of organizations* (pp. 972-1002). Chicago: Rand McNally.

Brown, A. L. (1989). Motivation to learn and understand: On taking charge of one's own learning. *Cognition and Instruction, 5*, 311-321.

Brown, J. S., Collins, A., and Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*, 32-42.

Buchmann, M. (1989). The careful vision: How practical is contemplation in teaching? *American Journal of Education, 98*(1), 35-61.

Carraher, T., Carraher, D., and Schliemann, A. (1985). Mathematics in the streets and in the schools. *British Journal of Developmental Psychology, 3*, 21-29.

Clancey, W. J. (in press). The frame of reference problem in the design of intelligent machines. In K. VanLehn (Ed.), *Architectures for intelligence*. Hillsdale, NJ: Erlbaum.

Cohen, D. K. (1988). *Teaching practice: Plus ça change . . .* (Issue Paper 88-3). East Lansing: Michigan State University, National Center for Research on Teacher Education.

Cole, M., and Griffin, P. (1980). Cultural amplifiers reconsidered. In D. R. Olson (Ed.), *The social foundations of language and thought: Essays in honor of Jerome S. Bruner* (pp. 343-364). New York: Norton.

Davis, P., and Hersh, R. (1986). *Descartes' dream: The world according to mathematics*. San Diego, CA: Harcourt Brace Jovanovich.

Dreyfus, H. L., and Dreyfus, S. E. (1986). *Mind over machine*. New York: The Free Press.

Feiman-Nemser, S., and Buchmann, M. (1985). Pitfalls of experience in teacher preparation. *Teachers College Record, 87*, 53-65.

Good, T., Grouws, D. A., and Ebmeier, H. (1983). *Active mathematics teaching*. New York: Longman.

Greeno, J. G. (1987). Mathematical cognition: Accomplishments and challenges in research. In T. A. Romberg and D. M. Stewart (Eds.), *The monitoring of school mathematics: Background papers. Vol. 2: Implications from psychology: Outcomes of instruction* (pp. 3-26). Madison: Wisconsin Center for Education Research.

Greeno, J. G. (1989a). A perspective on thinking. *American Psychologist, 44*, 134-141.

Greeno, J. G. (1989b). Situations, mental models, and generative knowledge. In D. Klahr and K. Kotovsky (Eds.), *Complex information processing: The impact of Herbert A. Simon*. Hillsdale, NJ: Erlbaum.

Greeno, J. G. (in preparation). *Some conjectures about number sense*.

Isenberg, D. J. (1984). How senior managers think. *Harvard Business Review, 62*(6), 80-90.

Jackson, P. W. (1988). *The practice of teaching*. New York: Teachers College Press.

Kotter, J. P. (1982). *The general managers*. New York: The Free Press.

Lave, J. (1988). *Cognition in practice: Mind, mathematics, and culture in everyday life*. Cambridge: Cambridge University Press.

Leinhardt, G. (1986, April). *Math lessons: A contrast of novice and expert competence*. Paper delivered at the annual meeting of the American Educational Research Association, San Francisco.

Leinhardt, G., and Greeno, J. (1986). The cognitive skill of teaching. *Journal of Educational Psychology, 78*(2), 75-95.

Leinhardt, G. and Smith, D. A. (1985). Expertise in mathematics instruction: Subject matter knowledge. *Journal of Educational Psychology, 77*(3), 247-271.

Leinhardt, G. (in press). The development of an expert explanation: An analysis of a sequence of subtraction lessons. *Cognition and Instruction*.

Lortie, D. C. (1975). *Schoolteacher: A sociological study*. Chicago: University of Chicago Press.

Loucks-Horsley, S., Harding, C. K., Arbuckle, M. A., Murray, L. B., Dubea, C., and Williams, M. K. (1987). *Continuing to learn: A guidebook for teacher development*. Andover, MA: The Regional Laboratory for Educational Improvement.

Parsons, T. (1959). The school class as a social system: Some of its functions in American society. *Harvard Educational Review, 29*, 297-318.

Pea, R. (1988). Putting knowledge to use. In R. S. Nickerson and P. P. Zodhiates (Eds.), *Technology and education: Looking toward 2020* (pp. 169-212). Hillsdale, NJ: Erlbaum.

Rogoff, B., and Lave, J., (Eds.). (1988). *Everyday cognition: Its development in social context*. Cambridge, MA: Harvard University Press.

Scribner, S. (1984). Studying working intelligence. In B. Rogoff and J. Lave (Eds.), *Everyday cognition: Its development in social context* (pp. 9-40). Cambridge, MA: Harvard University Press.

Spiro, R. J., Vispoel, W. L., Schmitz, J. G., Samarapungavan, A., and Boerger, A. E. (1987). *Knowledge acquisition for application: Cognitive flexibility and transfer in complex content domains* (Technical Report No. 409). Champaign: University of Illinois, Center for the Study of Reading.

Steiner, H. G. (1988). Two kinds of "elements" and the dialectic between synthetic-deductive and analytic-genetic approaches in mathematics. *For the Learning of Mathematics, 8*(3), 7-15.

Stevenson, H. W., Lee, S. Y., and Stigler, J. W. (1986). Mathematics achievement of Chinese, Japanese, and American children. *Science, 231*, 693-699.

Stigler, J. W., and Baranes R. (1988). Culture and mathematics learning. In E. Rothkopf (Ed.), *Review of research in education* (Vol. 15, pp. 253-306). Washington, DC: American Educational Research Association.

Suchman, L. (1987). *Plans and situated actions*. New York: Cambridge University Press.

Tymoczko, T. (Ed.). (1985). *New directions in the philosophy of mathematics*. Boston: Birkhauser.

Weizenbaum, J. (1976). *Computer power and human reason: From judgment to calculation*. San Francisco: W. H. Freeman.

Winograd, T., and Flores, F. (1986). *Understanding computers and cognition: A new foundation for design*. Norwood, NJ: Ablex.

Wittgenstein, L. (1953). *Philosophical investigations*. New York: Macmillan.

Zuboff, S. (1988). *In the age of the smart machine*. New York: Basic Books.